EENGR 330 – ENGINEERING SERVICE PROJECT I

Lighting Plan

Recommendations for Habitat for Humanity in White County

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12/8/2011

ABSTRACT: Research was conducted in order to determine which lighting options were good choices for Habitat for Humanity homeowners in White County, AR. In particular, lighting was studied to determine its initial cost, energy cost, lighting quality, safety, and sustainability, that is, how easy it would be to maintain or replace lighting fixtures. What was discovered was that compact fluorescent bulbs (CFLs) tended to be the best option based on their cost (per bulb + energy). While LEDs seemed to be a better choice in terms of longevity and environmental impact, the cost per bulb was just too high. Until the cost of LEDs goes down significantly, the best choice is to use CFLs.

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Introduction

Lighting is often one of the most expensive energy costs in maintaining a home. With the advancement of lighting technologies, it seemed fitting to delve into these new options with the aim of reducing costs for the homeowner. For Habitat for Humanity (hereafter referred to as HFH) in particular, keeping costs to a minimum while not sacrificing quality was a huge goal. The lighting requirements for each type of room in the house had to be taken into account.

Any results obtained from research could be used not only in the next house build in White County, but in future HFH builds around the country. Few assumptions were made about the current lighting plans employed by HFH.

Objectives/Specifications

To create a set of lighting recommendations that provides cost-efficient, reliable, safe, and sustainable lighting for HFH homes. The costs of the lighting system were to be examined over a 20 year period. The lighting provided should accommodate rooms that typically need more light, such as the kitchen and bathroom.

The goal was not to create a physical map of the lighting layout for the house, but to prepare a guide for choosing the type of lighting to implement.

Conceptual Designs/Alternatives

Several methods for lighting were researched, including natural lighting, such as skylights, and three kinds of bulbs: incandescent, compact fluorescent (CFL), and light-emitting diode (LED).

While sky lighting is the most environmentally friendly (and perhaps the most aesthetically pleasing), the initial cost of installation is too high. Although they save energy by warming the house during the day, they also tend to make insulation more difficult and can let a significant amount of heat escape, especially at night. Another important factor considered was that the HFH homes would be built mostly by volunteers who don't have the necessary training to install such windows. Maintenance as well would be more difficult for the homeowner if skylights were used. Skylights provide the largest payoff when used in large buildings and are installed by professionals. For a small home, such as most HFH builds, the energy savings is not enough to justify their use.

Incandescent bulbs have long been the primary lighting for most buildings. They are cheap to make, easy to find, and produce a very pleasantly colored light (~5500K). However, their energy use is often very wasteful, as up to 90% of the energy used by them is given off as heat, rather than light. This not only uses more energy to light a room, but can make it more difficult to properly heat and cool the room as well.

Compact fluorescent bulbs, on the other hand, tend to use about 1/6 of the energy that incandescent bulbs use and can last ten times as long. The cost per bulb is only a little higher than incandescent bulbs. The CFL does have some disadvantages, however. The color temperature of CFLs is often not as aesthetically pleasing as that of incandescent bulbs, although they have improved significantly since being first put on the market. While the lifetime of CFLs

is greatly increased from that of incandescent bulbs, it can be shortened by turning the bulb off and on repeatedly. Also, the bulbs tend to take several seconds to turn on fully and can dim over time, while incandescent bulbs can turn on instantly and never dim until they finally burn out. A final consideration with CFLs is that they do contain mercury in them, which could be dangerous if the bulbs break. However, the amount of mercury is not large enough to pose a significant threat in most cases (Quinton, 2010).

LEDs are much newer to the market, and as a result, are often much more expensive per bulb than either incandescent bulbs or CFLs. Their energy savings and great lifespans, however, have the potential to make the investment worth it. Unlike CFLs, LEDs can turn on instantly and can be cycled (turned on and off) frequently without damaging the bulb. They also contain no mercury and emit very little heat. The biggest issues with LEDs at present are the color temperature, which is comparable to that of CFLs, and the hefty price tag for each bulb. Also, the light from the LEDs tends to be very directional, which can make it difficult to light an entire room.

The total cost (purchase costs plus energy costs to use) of each kind of bulb was compared using data from (O'Neill, 2008) with the price of electricity given as $0.23/kWh. The rest of the data used can be found in Table 1 provided in the Appendix.

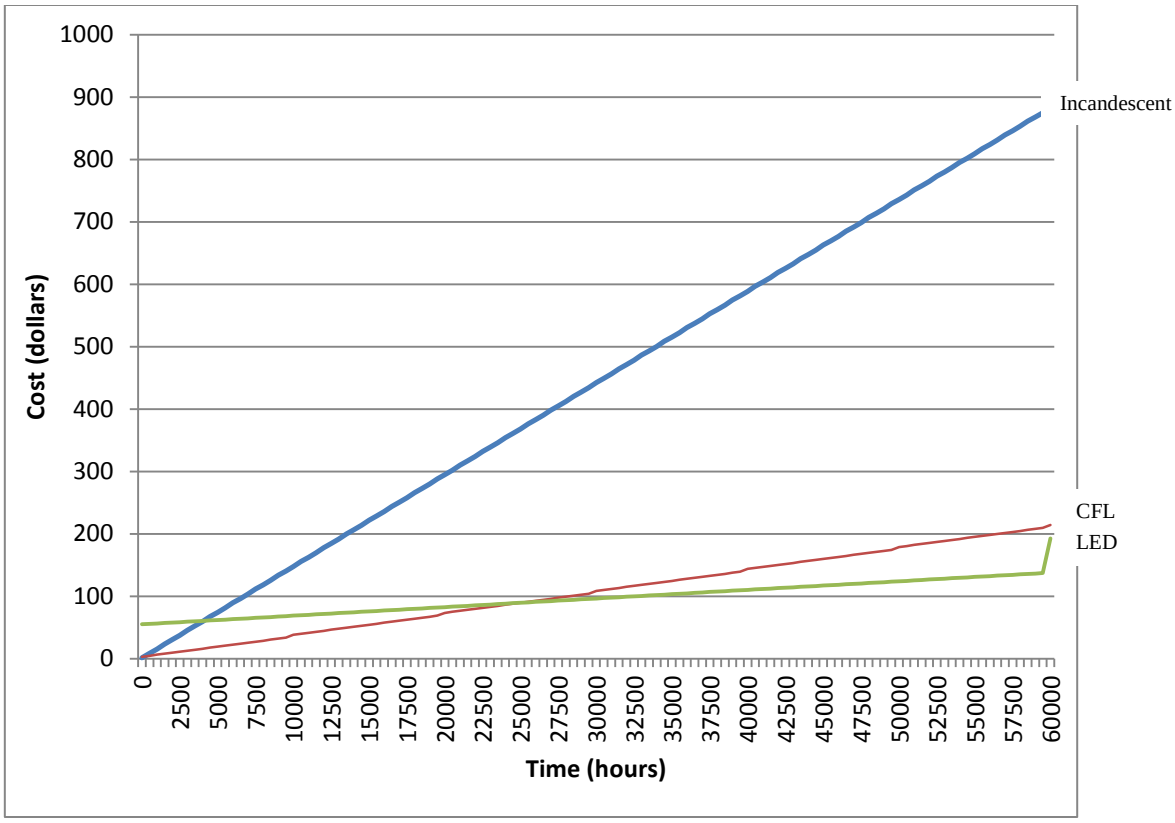

FIGURE 1 Cost comparison for Incandescent, CFL, and LED light bulbs.

Each "jump" in a series represents the cost of replacing a bulb. If the light bulbs are used about 8 hours per day, the 60,000 hours of bulb use shown approximates 20 years of house life.

According to this set of data, the LED is cheaper than the CFL after about 25,000 hours (8-9 years) of use. From this initial research, LEDs seemed to be the clear choice for lighting new homes while incandescent bulbs are so expensive that we will not consider them further.

Findings/Results

Further research was conducted to find which specific model of LED would be the best for these homes. The same analysis as in Fig. 1 was conducted with six different LEDs and an average CFL to see their total cost over 20 years of use. The results are shown in Fig. 2.

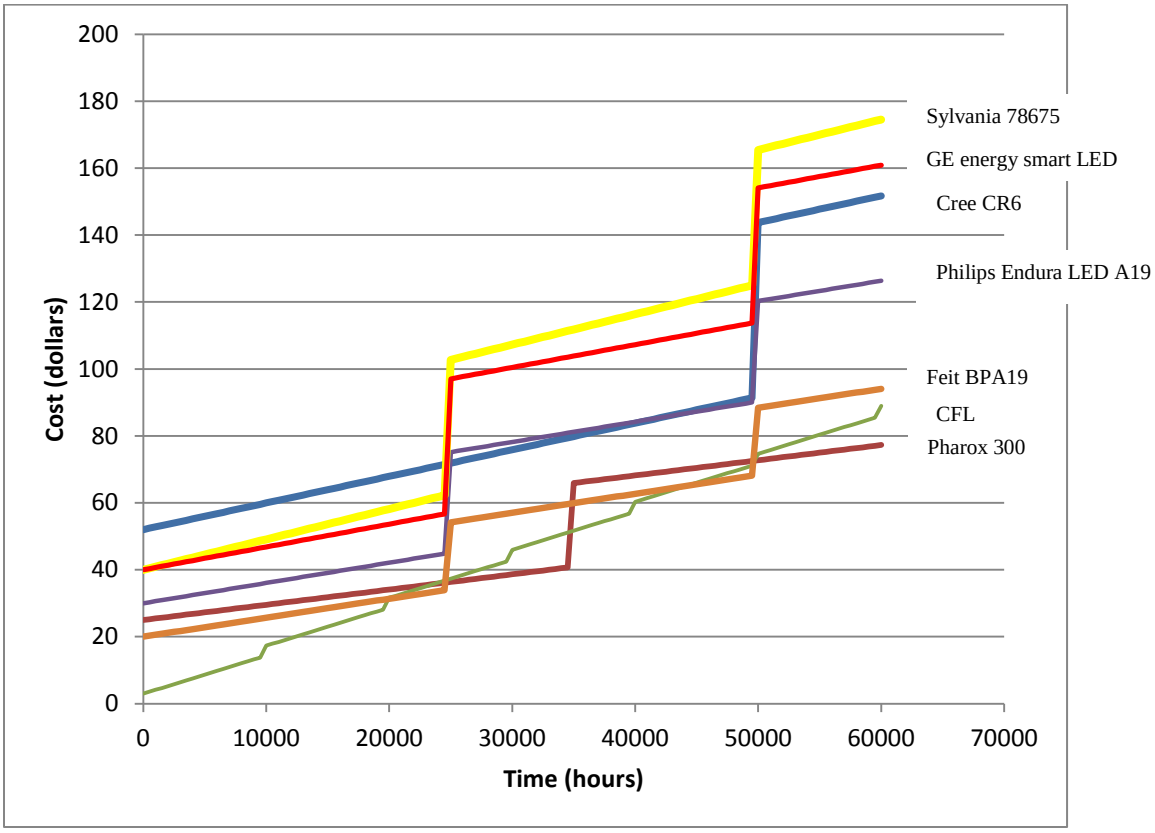

FIGURE 2 Cost comparison for six different kinds of LEDs and a generic CFL.

Instead of using the data provided by (O'Neill, 2008) for the cost of LED bulbs, energy cost, lifespan, and wattage, data was collected from six different LED manufacturers and compared to the original CFL estimates. The original electricity price of $0.23/kWh (O'Neill, 2008) was replaced with the Arkansas 2009 average of $0.0757/kWh (Energy Information Administration, 2011). This difference in electricity price caused a surprising change in results from the original analysis. From this analysis, nearly all the LEDs ended up costing more than the CFL in a 20-year timeframe. While the LEDs looked as though they might save money at some point in the future, it would be very difficult to accurately predict the cost of anything beyond 20 years, so the extrapolation would not have been useful. Because of the low energy

prices in Arkansas, the money saved in electricity by using LEDs is not enough to offset the purchase price of each bulb. The data used in Fig. 2 is provided in the Appendix.

From Fig. 2, only one of the examined LEDs, the Pharox 300, is cheaper than a standard CFL. However, given that the typical 60 W incandescent (the standard in most houses) provides about 900 lumens, the 300 lumens provided by the Pharox 300 would not be sufficient enough for residential general lighting.

A possible solution to the high LED bulb price this was discovered in the research, however, as it was discovered that Cree, one of the forerunners in the LED industry, had pledged to provide each new HFH home built in 2010-2012 with free CR6 down lights for its kitchen (Koch, 2010) . Since the kitchen was identified earlier as one of the rooms that typically needs more light, the directional light from LEDs would be a good candidate for task lighting in the kitchen. Unfortunately, attempts to obtain these lights from Cree have not been met with success so far.

Conclusions

While LEDs appear to be the best lighting choice in terms of reliability and safety, the cost of LED bulbs at the present argues strongly in favor of using CFLs. Perhaps in the future the cost of LEDs will decrease enough (or the cost of electricity will increase enough) that they will be a money-saving option, but for now the best choice is to use compact fluorescent bulbs.

Appendix

	Incandescent	CFL	LED
Bulb cost ($)	1.345	2.98	54.95
Wattage (W)	60	14	6
Lifespan (hrs)	1500	10000	60000
Lumens (lm)	890	900	577.5
Energy cost ($/hr)	0.0138	0.00322	0.00138

TABLE 1 Data used for Fig. 1

	CFL	Cree CR6	Pharox 300	Philips Endura LED A19	Sylvania 78675	Feit BPA19	GE energy smart LED
Bulb cost ($)	2.98	52	25	30	40	20	40
Wattage (W)	15	10.5	6	8	12	7.5	9
Lifespan (hrs)	10000	50000	35000	25000	25000	25000	25000
Lumens (lm)	900	577.5	360	800	810	450	450
Color Temperature (K)	N/A	2700	N/A	2700	2700	3000	3000
Energy cost ($/hr)	0.0011355	0.00079485	0.0004542	0.0006056	0.0009084	0.00056775	0.0006813

TABLE 2 Data used for Fig. 2.

Works Cited

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